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Editorial

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Wasted talent: the status quo of women in physics in the US and UK

Women+ continue to face obstacles at each step along the way of pursuing a scientific career, and physics has one of the lowest gender diverse participation of all STEM subjects. This is a tremendous waste of potential that can only be reversed with a significant cultural change by all participants.

International Women's Day (IWD) is an opportunity to recognise and celebrate the social, economic, cultural, and political achievements of women+, and this includes their contribution to science. This day is also associated with events to raise awareness about global needs and actions to accelerate women +'s equality in all aspects of life.

While women have been involved in scientific discovery from the earliest times[1], the acknowledgement of their contributions continues to be undermined by a conservative culture in many scientific fields. Sadly, the field of physics is a paragon of the multiple structural and societal hurdles women+ face in pursuing scientific careers. As a journal disseminating and promoting contemporary discoveries in physics, we take the occasion of the IWD to reflect on the persistent obstacles women+ face in the scientific ecosystem. With this editorial, which is part of a collection of interviews and comments dedicated to Women in Physics, we wish to take a snapshot of the current physics landscape, from engaging girls in schools, to undergraduate enrolment, from scientific recognition to scientific leadership. Here we will consider only a few elements of the present outlook for women+ physicists and draw inspiration from some of the successful initiatives aimed at improving the status quo, rather than trying to provide an overview of what is a long-standing and complex discourse. While we will focus on the UK and US, which are where the authors are based, there is evidence that the picture is not dissimilar in other parts of the world with a high output of physics research, particularly in Asia (see, e.g. ref. 2).

In western countries there is a general negative cultural attitude towards girls and young women + studying physics, principally driven by the stereotype that girls do not like mathematics (see for example ref. 3). This has the effect that girls can find it harder to identify themselves with physics professions. To counteract this behaviour, the UK-based Institute of Physics (IoP) has been running the Limit Less Campaign since 2020. Changing culture and attitude requires schools to make physics an interesting and inclusive subject to study. The misconception that mathematics is difficult and more suitable for boys needs disproving. One way of doing so is by highlighting the funny, engaging and rewarding aspects of solving mathematical problems, but also by showcasing women+ in physics as role models, so that more girls can see themselves as future physicists.

The dire situation of girls studying physics in schools naturally reflects on the university population. At present, only 24–25% of physics degree recipients in the UK[4]/US[5] identify as women+. In the US, there has been no improvement since 2005 and physics, along with computer science and engineering, has the lowest participation ratio of women+. In the UK the percentage of women physics undergraduates has only increased by 3% points from 2012/13 to 2017/18, and a high proportion of this growth has been driven by foreign women choosing to study physics in UK universities[4]. This is in contrast with other sciences. For example, in biology and chemistry respectively, 60% and 50% of the degrees are obtained by women, and these percentages have been steadily increasing since the 1970s[4]. In the USA this increase appears to coincide with the introduction, in 1972, of Title IX[6], making discrimination on the base of gender illegal by any institution receiving federal funding. However, Title IX has proved way less effective when looking at the physics landscape, suggesting that this important landmark was not the only reason for the change of behaviour in other subjects, and the lack of progress in physics is seemingly linked to a long-standing implicit bias. This despite the efforts by the American Physical Society (APS), since the early 70s, in creating committees focused on raising awareness of the limited recognition of women physicists[7]. We believe that one possible issue is that those policies focused on enhancing outreach with women serving as role models, improved recognition of women physicists and provided initial networking opportunities at meetings. The committees, however, did not address implicit bias and active structural gender discrimination.

Between 2003 and 2005 the IoP initiated a project to investigate the issues students and staff in UK university physics departments face. The concerns most reflected by the institutions surveyed were around lack of recruitment, retention, and progression of women+. As a result of this research, Project Juno was created: an equality, diversity, and inclusion (EDI) award framework to encourage physics university departments to follow, evidence and champion good practices within six principles covering these areas. Over 44 UK universities were engaged in Project Juno. This year (2024) it is being replaced with the IoP Diversity Inclusion Model.

In 2006 the APS started yearly regional CUWiP (Conference for Undergraduate Women + in Physics) conferences. These events serve multiple purposes: students are exposed to top research by leading women+ physicists, they engage on topics related to being a minority, they participate in professional development opportunities, and they build their first network of peers. Following the success of CUWIP in the USA, in 2015 Professor Daniela Bortoletto introduced CUWiP+ to the UK, which is now supported by the IoP. Other one-day events hosted by various universities and aimed at women+ postgraduate students have since been established (e.g. KCL Womxn in Physics). In addition, academic institutions are creating dedicated women+ in physics groups providing supportive communities of, and for, women+. Activities in these groups can range from informal gatherings to consolidating a network of women+ peers, to providing confidence building tips and workshops, from developing outreach

activities focused on women+ audiences, to organising lecture series highlighting women+ achievements, and creating opportunities to interact with role models who can offer career advice and inspire them in embracing a career in science While men would access such networks naturally, in light of the man-dominated environment, statistically, women undergraduates would not. In the UK, only 12% of professorships are held by women while this increases to 26% for all other subjects combined[8]. In the US, 19% of the physics faculty are women, however most women are in non-tenure eligible teaching-only positions, and when we only consider PhD granting institutions, the average drops to 16%[9]. The percentage of women drops with prestige and seniority at each level, and exacerbates the initial societal bias at all career stages. These statistics clearly showcase the amount of pressure on women+ academic staff in providing that important exemplary "role model" to younger generations, and serves as a reminder that increased outreach to counter societal and cultural bias is not enough.

To tackle the problem at advanced stages of a physics career, the current academic environments require a culture shift which embraces diversity. An encouraging example comes from the astronomy community in the USA, which has been a field leading this paradigm change. The 1992 Baltimore Charter for Women in Astronomy[10] is a manifesto for women acknowledgement and promotion in the astronomy community, and its recommendations were adopted by various departments. Affordable childcare, parental leave, extension of the tenure-clock and publishing codes of conduct are some of the aspects where the Charter provides guidance to a more inclusive environment. In addition, prizes and fellowships started to allow self-nominations. Over the past 30 years, all these changes combined led to a doubling of women percentages at the full professor rank, in prize winners, in prestigious leadership positions and post-doc fellowships. The change has been so rooted that the current generation wants to be seen as women astronomers[11], whereas only two decades ago women tried to blend in and hide their gender.

To make progress in physics, a similar culture shift is necessary. The challenges women+ face cannot be reduced to different cultural expectations linked to traditional family roles. In fact, women+'s scientific achievements do not receive the same recognition as men, and this bias affects all aspects of a scientific career: from access to academic positions to the publishing world. The visibility of women+ in the academic and public sphere is significantly less than that of men, with a lower rate of women+ promotion over that of men, by being underrepresented as plenary speakers, contributing to panels, and as prize winners. They are more often omitted as co-authors from publications[12] and there are several studies showing that women+ are cited at lower rates [e.g. refs. 13–15]. These are only a few examples that demonstrate that women+ are not represented in national and international leadership positions, exacerbating the problem further. As a recent study discusses, this persistent under-recognition of women+'s contributions is the leading cause for senior women+ to leave academia at a higher rate than early career women+[16]. These data indicate a two-fold failure of the physics community: not only does it fail at attracting young women+, but it is also willing to forfeit the scientific expertise matured over years of invested commitment to science.

To counter some of these structural and cultural barriers and improve equity among scientists, an exemplary approach comes, once more, from the broad field of astronomy. After the initial successful implementation for the Hubble Space Telescope[17], NASA has introduced a double-anonymous review for observational time on all their telescopes. The double-anonymous review improved the acceptance rate for women + compared to previous years, making it similar to that of men. Allowing for self-nominations, improving transparency in selection processes and criteria can reduce unconscious bias in nominations and selection of candidates and proposals.

The removal of structural barriers will be instrumental, but until a change of the reference system to identify "who is a physicist" occurs, physics is bound to lose women+ talents. As major physics discoveries face increasingly ambitious problems, it is time to get rid of the old-fashioned "lone (male) genius myth", and start tapping into the rich pool of talented women+. For this cultural shift to occur, awareness and active change must be supported not only by women, but importantly by the man-dominated physics leadership in individual departments, universities, and physical societies. It is well proven that committed leadership can have significant effects in enacting change, and the process undoubtedly requires training in hiring and personnel management. This change starts by acknowledging that gender diversity in physics has made little progress in the US/UK in the last 20 years, that an enormous number of skilfull early careers and experienced women+ physicists have been lost and that passive waiting for new generations and minorities to lead the change is insufficient.

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